CHAPTER 9
SUMMARY AND CONCLUSION

9.1 SUMMARY

In this thesis, the CAD system for early detection and classification of ischemic stroke in CT image, hemorrhage and hematoma in brain CT image and brain tumor in MR image using k-means clustering with classifiers for diagnosis of diseases are implemented. Three different brain diseases are taken for investigation. The brain region related to a lesion is exactly separated from the brain image using segmentation. A quantitative analysis is performed for all brain diseases. In this research work, ischemic stroke (normal and abnormal), four different types of brain hemorrhage and hematomas and five different types of brain tumors are classified. The performance of the classifiers is evaluated in terms of sensitivity, specificity and accuracy. There is no human intervention.

The CAD system of brain abnormality detection and classification has several stages including image pre-processing, image segmentation, feature extraction, feature selection and classification. The most common classification methods that have been applied in this research work include, SVM, ANN and decision tree.

In the ischemic stroke detection and classification the lesion region is located using k-means clustering and texture features. This approach detects ischemic stroke in routine non-enhanced brain CT images. In the ischemic stroke detection
and classification midline of the brain is traced and then fourteen texture features are extracted using GLCM. Seven optimal features are selected using GA. The seven optimal features are derived from the left and right side of the brain. These features are ASM, contrast, entropy, correlation, IDM, variance and dissimilarity. The derived features are used to train the binary classifier, which automatically classifies as a normal brain or an ischemic brain, suffering from a brain lesion.

The results are quantitatively evaluated by a human expert. The average overlap metric, average precision and the average recall between the results obtained using the proposed approach and the ground truth are 0.98, 0.99 and 0.98, respectively. The experimental results obtained from different stages of ischemic stroke detection are discussed.

In hemorrhage and hematoma detection and classification, the lesion region is located using k-means clustering and texture features are used to classify the type of hemorrhage and hematoma. This system detects hemorrhage and hematoma in routine non-enhanced brain CT images. Hemorrhage and hematoma region is located using k-means clustering. The results are quantitatively evaluated by a human expert. The average overlap metric, average precision and the average recall between the results obtained using the proposed approach and the ground truth are 0.85, 0.80 and 0.97, respectively.
When the lesion regions are defined, features are computed to represent regions for analysis, characterization and classification. These features include the texture information of the regions. Initially 14 texture features are extracted from the lesion region. Then thirteen features are selected using GA. These features are ASM, contrast, IDM, entropy, correlation, sum of squares, difference entropy, inertia, cluster shade, cluster prominence, homogeneity, dissimilarity and difference in variance. Then these optimal features are fed to classifiers to classify the four types of hemorrhage and hematoma (EDH, ICH, SAH and SDH).

In the brain tumor detection and classification the brain tumor is separated from healthy tissues in MR images based on k-means clustering and texture features. The MR feature images used for the tumor detection consist of T2-weighted magnetic resonance images for each axial slice through the head. In tumor detection, the lesion region is extracted by using k-means clustering technique. The results are quantitatively evaluated by a human expert. The average overlap metric, average precision and the average recall between the results obtained using the proposed approach and ground truth are 0.80, 0.82 and 0.87, respectively. The proposed system has successfully tested on brain images causing brain tumor in a large scale.

Fourteen texture features are extracted by using GLCM of the tumor region. The ten optimal features are selected using GA. They are ASM, contrast,
entropy, correlation, sum of squares, difference entropy, IDM, inertia, cluster prominence, cluster shade, energy, homogeneity, dissimilarity and difference in variance. The ten optimal features are used to train the classifier, which can automatically classify the types of brain tumor image, suffering from a brain lesion. These 10 optimal features are fed into the classifiers.

Classification is the final step in the diagnostic process, where the optimal features are utilized to classify the type of brain CT and MR images. This approach is developed for the classification of normal and ischemic stroke brain CT, the type of brain CT hemorrhage and hematomas and the type of the MR brain tumor images using classifiers.

The classifiers are tested with different inputs to measure the performance. In ischemic stroke, 50 images are considered as training set and 35 images are considered as testing set. In CT brain hemorrhage and hematoma, 200 images are considered as training set and 120 images are considered as testing set. The number of MR brain tumor images in the input data set is 200 abnormal brain images of astrocytoma, medulloblastoma, glioma, glioblastoma multiforme and craniopharyngioma and 125 images are considered as testing set.

The results obtained from the SVM, ANN and decision tree classification models are discussed. The performance of the SVM model in diagnosing ischemic stroke, hemorrhage and hematoma and brain tumor is 97%, 98% and
98%, respectively. The proposed system has successfully tested on small lesion causing the hemorrhage and hematoma. The performance of the ANN model in diagnosing ischemic stroke, hemorrhage and hematoma and brain tumor is 94%, 94% and 97%, respectively. The performance of the decision tree model in diagnosing ischemic stroke, hemorrhage and hematoma and brain tumor is 91%, 93% and 95%, respectively.

In terms of performance, the SVM has consistently out-performed both ANN and decision tree. The sensitivity, specificity, accuracy and EER value for all the three models are calculated and accuracy is higher only in the SVM than the other models.

The application of the CAD system for early detection of ischemic stroke, hemorrhage and hematoma and the brain tumor is demonstrated to improve efficiency and accuracy of clinical practice hence it decreases the risk of misdiagnosis and mismanagement. The proposed system can help the physicians to identify the type of ischemic stroke, the type of human brain hemorrhage and hematoma and the type of brain tumors for further treatment. In this chapter the thesis is concluded by explaining the contributions of this research work with respect to each stage of the computer based brain abnormality diagnostic system. Among the three classifiers the SVM classifier is shown to be highly effective in the classification of brain lesions. This method is fully automatic as it does not require any human intervention. The contributions of this research work are
given in the next section. At the end, suggestions are provided for the future work.

9.2 CONTRIBUTIONS OF THIS RESEARCH WORK

The proposed approach makes contributions in various stages in the development of a CAD system of brain diseases; namely, image segmentation, feature extraction, feature selection and classification. A CAD system is developed for the early detection of ischemic stroke, hemorrhage and hematoma and brain tumor using k-means clustering in CT and MR images to increase the detectability. The brain region related to a lesion is exactly separated from the brain image using segmentation. The types of the brain diseases are classified by using SVM, ANN and decision tree classifiers. The research reported in this thesis is an attempt to improve some of the existing algorithms. The newly developed method is accurate, fast and reliable for computer-based diagnosis of brain diseases. The major contributions of this research work are:

1. An automated method is developed for the classification of ischemic stroke in CT, four different types of hemorrhage and hematoma in brain CT and five different types of tumors in brain MR images using SVM, ANN and decision tree classifiers.
2. Quantitative analysis is performed for ischemic stroke, hemorrhage and hematoma and tumor.
3. The optimal subset of texture features is determined by using GA to improve the classification accuracy.

4. The texture features based on classification system is established by using SVM, ANN and decision tree.

9.3 DIRECTIONS FOR FUTURE RESEARCH WORK

There is scope for future research work concerning to improve the performance of the CAD system.

- This method can be further extended to segment other types of images (PET, MRS and fMRI) with few modifications.
- One can incorporate the CT and MR image information together to obtain more accurate lesion segmentation.
- The system can be further enhanced to classify other types of tumors with few modifications.
- The system can be modified to classify the grades of the tumor types.
- An interesting extension of this thesis will be to investigate and quantify the patterns extracted from other modalities and fuse them with the patterns employed in the present research work.
- In this thesis, an ANN model is used to classify the types of diseases. Its network accuracy can be further improved by training it on a larger data set.